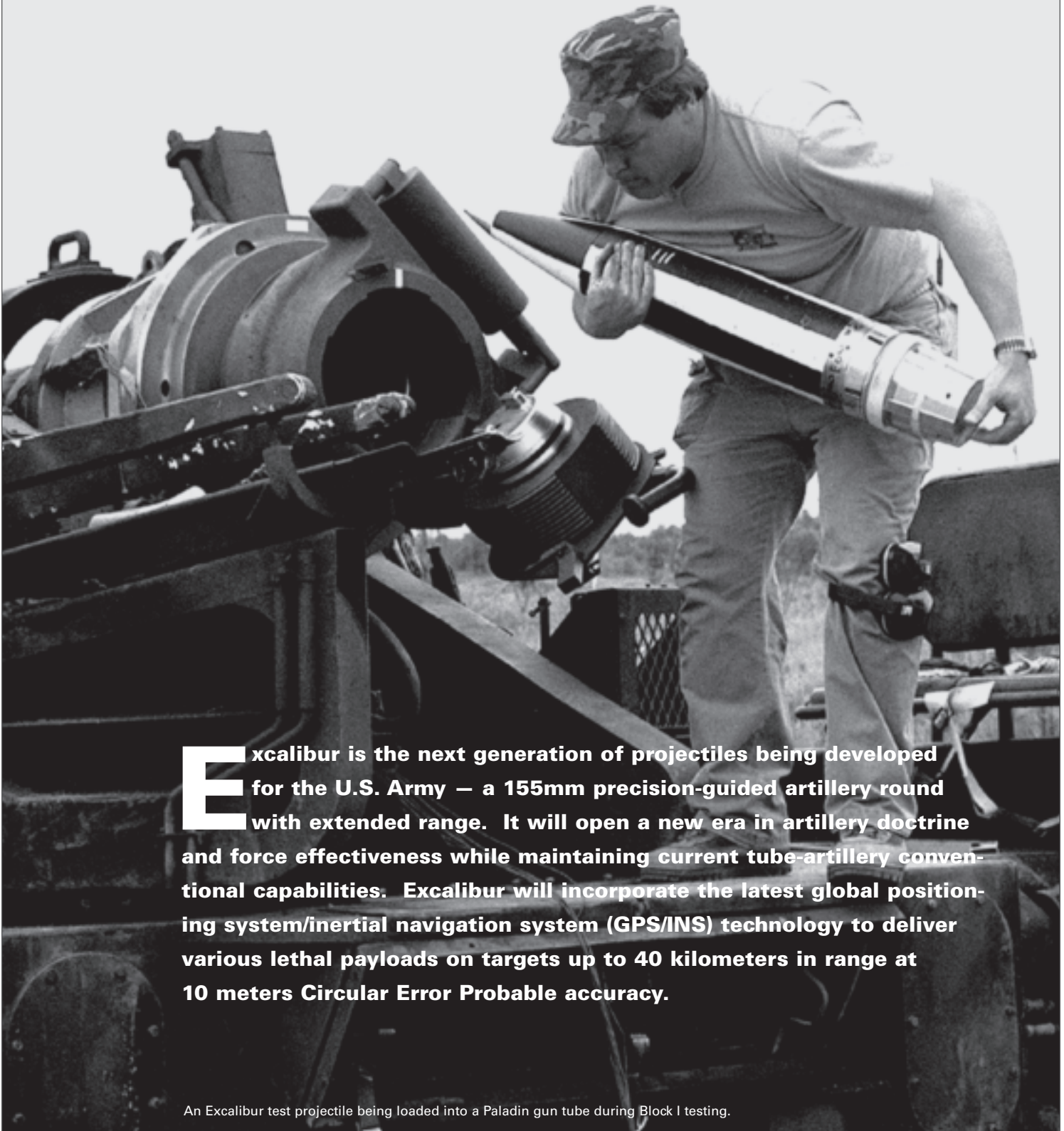


# Excalibur — Precise, Lethal and Cost-Effective

Chris Grassano



**E**xcalibur is the next generation of projectiles being developed for the U.S. Army — a 155mm precision-guided artillery round with extended range. It will open a new era in artillery doctrine and force effectiveness while maintaining current tube-artillery conventional capabilities. Excalibur will incorporate the latest global positioning system/inertial navigation system (GPS/INS) technology to deliver various lethal payloads on targets up to 40 kilometers in range at 10 meters Circular Error Probable accuracy.

An Excalibur test projectile being loaded into a Paladin gun tube during Block I testing.

The projectile's modular design incorporates three unique payloads, which will make Excalibur the most versatile artillery projectile in the Army arsenal. With the evolving current operational environment, the 155mm Excalibur projectile will enable the maneuver commander to precisely defeat critical targets while also minimizing collateral damage and unexploded ordnance.

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Block I will provide a unitary warhead payload capability for the Joint Lightweight 155 (JLW155) in FY06. Paladin and Future Combat Systems Non-Line-of-Sight-Cannon capabilities will follow. The Block I Unitary variant has three increments, each of which will provide incremental time-phased performance capabilities to the warfighter.

Block II will incorporate a smart submunition payload. Block III will use target-discriminating technology to seek, detect, discriminate and defeat specified targets. Future improvements to all blocks will allow for technology refresh and insertion of user requirements to be identified throughout the projectile's life cycle.

The Excalibur development strategy is based on integrating acquisition reform tenets to include evolutionary acquisition and spiral development, performance specifications and open architecture, integrated product and process development (IPPD), concurrent engineering (CE), integrated data environment, alpha contracting, cost as an independent variable (CAIV), earned value management system, risk management, simulation and modeling for acquisition requirements and training (SMART), Six Sigma and Lean Design principles, single process initiatives and aggressive and nontraditional test and evaluation (T&E).

## Evolutionary Acquisition and Spiral Development

The Excalibur Program is an Acquisition Category IC program managed by the Program Executive Office for Ammunition at Picatinny Arsenal, NJ. The Excalibur family of munitions will be developed, produced and fielded in incremental, evolutionary blocks.

## Performance Specifications and Open Architecture

The acquisition strategy for the Excalibur projectile was competitively solicited using a performance specification, which satisfied the Operational Requirements Document (ORD). All system-level performance requirements flowed down to individual subsystem performance specifications and interface control documents (ICDs). ICDs are managed by the Interface Control Working Group to ensure interoperability with all supported and supporting systems.

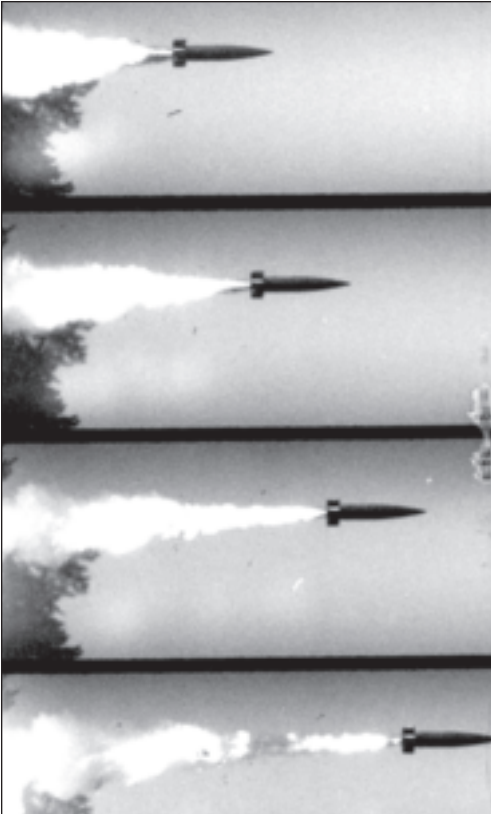
In the current contract, the Excalibur Product Management Office (PMO) invokes no military specifications and only three military standards. Excalibur's open system architecture is based on open system standards as a performance requirement. This will greatly facilitate the incorporation of technology refreshers throughout the projectile's future development and production phases.

## IPPD

The Excalibur program has embraced an IPPD approach to facilitate open communication between the contractor and government teams with

An Excalibur test projectile is being fired from a Paladin gun tube during field testing.





An Excalibur test projectile races to target during basebleed testing. Photo at far right is a close-up of Excalibur.

representation from appropriate disciplines in a true CE environment. The teams are given responsibility for developing discrete system elements within allocated cost, schedule and performance parameters. The Excalibur government support and systems contractors have been organized using integrated product teams (IPTs) including ones for program management, projectile, systems engineering, guidance navigation and control, T&E and cost performance. The user is an integral part of the management team and is represented in all performance trade-off studies to ensure ORD adherence.

## IDE

The PMO required that a contractor-developed, integrated technical information system be established containing all applicable documents and drawings associated with Excalibur projectile development. To encourage ad hoc and working-level meetings, the system uses a Web-based, real-time

collaboration environment. All government and prime subcontractor participants have access to the system.

## CAIV and Cost-Reduction (CR)

The cost-performance IPT — which includes PMO, user, government matrix technical support and contractor representatives — manages the CAIV and CR processes per Office of the Secretary of Defense (OSD) and Army guidance. The objective is to meet the user's desired key performance parameters while minimizing cost. CAIV trade-offs were made with the user while the ORD was being developed and will continue throughout the development program. Many requirements were time-phased and grouped into capabilities to be fielded in increments. CR initiatives were generated by systematically applying Lean Design and Lean Manufacturing principles.

## Risk Management

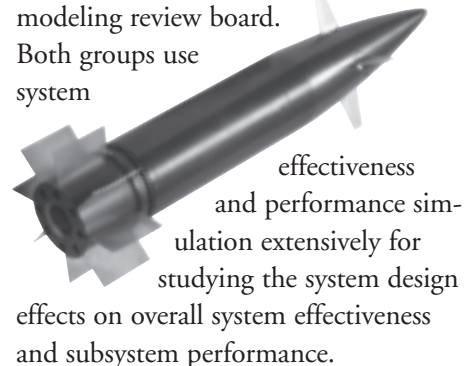
The Excalibur risk management program's goal is to identify and mitigate risk by instituting a formal review process to ensure that the program's Acquisition Program Baseline requirements are met. It is managed by a Risk Management Board (RMB), and all program participants have an opportunity to identify program cost, schedule and performance risks. Risks are characterized as high, medium or low, depending on the probability of occurrence and severity of impact to the program.

High-risk items require immediate action by the IPT lead whose area is affected. That IPT is required to

study the risk and present a mitigation plan at the next RMB. Mitigation plans for medium- and low-risk items are briefed by request or after successfully executing the mitigation plan.

## Planning for SMART

The Excalibur program relies extensively on SMART. Structural design analysis as well as system effectiveness and performance estimate verification rely on computer-based modeling and simulation (M&S). Finite element analyses are conducted prior to all structural testing to ensure adequate design. Both the government and contractor share responsibility for conducting this analysis by managing a joint industry-government modeling review board. Both groups use system



The acquisition strategy for the Excalibur projectile was competitively solicited using a performance specification, which satisfied the Operational Requirements Document.

## Aggressive and Nontraditional T&E

T&E is a significant portion of any development process, and the Excalibur T&E IPT has significantly reduced the number of projectiles required for developmental testing (DT) and operational testing (OT), compared to previous projectile development programs. The number of projectiles required to be tested for the traditional safety

series is 374. For the Excalibur program, the T&E IPT has reduced the quantity to 58. This was facilitated by

extensive use of design margin verified in M&S and testing at margin conditions. Operational testers will rely extensively on DT data, thereby reducing the OT requirements without sacrificing confidence in their assessment.

### Commonality

The Army recognizes that high precision-guided munitions development costs, when balanced against fiscal realities, require additional emphasis on affordability. To make Excalibur more affordable, the Army and Navy have established a process to objectively examine cooperation and commonality issues among their precision-guided munitions programs. An Army-Navy-OSD Executive Steering Committee and associated IPT are coordinating the development and production of these programs. Initiatives include opportunities to leverage research and development investments, foster competition through economies of scale and review potential component and system commonality areas.

### Technical Representatives at Contractor Facilities

Given Excalibur's technical and programmatic complexity, the PM

decided it was important that key technical representatives be physically located at the prime contractor's facility in Tucson, AZ, to coordinate, then execute, a disciplined systems development process. In addition, specific responsibilities of Defense Contract Management Agency (DCMA) representatives are clearly outlined in an approved Memorandum of Agreement that is updated as necessary. These representatives will participate in daily meetings and activities throughout program development and execution. DCMA Tucson issued a Letter of Delegation to DCMA Northern Europe to provide operations oversight of the major subcontractor, Bofors Defence, Karlskoga, Sweden.

The Excalibur guided projectile program is a key element of U.S. Army transformation to a strategically deployable, logistically supportable and highly lethal force. These 155mm artillery projectiles will allow the U.S. Army cannon artillery units to dominate future battlefields at extended ranges in support of the lighter Interim and Future Forces now being equipped and deployed. Excalibur features include low cost-per-kill,

increased survivability, extended range, fire-and-forget GPS/INS and a modular design strategy that means the same guidance and tail sections can be used for different warhead options.

**CHRIS GRASSANO** is the Deputy PM Excalibur, PMO CAS, Picatinny Arsenal. He holds a B.S. in electrical engineering from New Jersey Institute of Technology, an M.B.A. and an M.S. in management from Florida Institute of Technology. He has completed all programs on Leadership for Senior Executives at Harvard University and is a Defense Systems Management College Advanced Program Management Course graduate. Grassano is Level III certified in three career fields: program management; test and evaluation; and systems planning, research, development and engineering.



## Applying Six Sigma to Excalibur Reduces PALT

Faith Harder

In late 2000, the Army merged the 155mm XM982 Excalibur and the joint U.S./Sweden Trajectory Correctable Munitions (TCM) program into a single cooperative program to develop a precision-guided, extended-range projectile. The biggest challenge was to cut the development cycle from 24 months to less than 1 year to meet the expectations of COL Nathaniel H. Sledge Jr., the Project Manager for Combat Ammunition Systems (PM CAS).

PM CAS is a Six Sigma organization, so it was natural that team members Faith Harder, the PM's Acquisition Analyst; Scott Cawood, International Project Engineer; and Cynthia Schoner, Contracting Officer; use this approach. The Six Sigma methodology's fundamental objective is implementing a measurement-based strategy that focuses on process improvement and variation reduction through the Six Sigma improvement project application.

The objective was to achieve a 50-percent reduction in the Procurement Administrative Lead Time (PALT) and award an Excalibur contract modification that would effectively merge the U.S. and Swedish extended-range projectile programs. The process team used its Six-Sigma tool kit to accomplish the mission, including cause-and-effect analysis, failure mode and effects analysis and house of quality to identify and prioritize issues and define improvement processes. Level I and II